

# Energy Efficient and Lower Capital Cost – an Alternative Data Center Cooling Strategy



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**Clustered Systems Company**  
*extreme green electronics cooling*

- \* This conference paper presents a novel cooling strategy for IT equipment that has been shown to be more energy efficient than other commercially offered cooling solutions.
- \* This conference paper also shows a technology that has the ability to provide cooling with higher temperatures which would reduce or eliminate the need for compressor based cooling.

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## \* Learning Objectives

# Presentation Outline

- \* Introduction /background
- \* Traditional air cooling issues
- \* Close coupled liquid cooling options
- \* Direct touch cooling
- \* Performance results
- \* Conclusions
- \* Q&A

- \* Server power and power density increasing again after period of stability
- \* PUE's getting better but high end is reaching limit of air cooling
- \* Power management and virtualization creating additional complexity
- \* Modular cooling solutions becoming popular, compared in “chill-off 2”

## Introduction

- \* Air is a very inefficient cooling medium
  - \* Low specific heat, need to move very large volumes
  - \* Gas to solid thermal resistances are high, large temperature differentials required
- \* Air mixing and “shadow” effects increase required temperature differentials further
  - \* Drives up cost of cooling
- \* Power densities are limited

## Air Cooling issues

# AIR

30C



Fan



Heatsink

>37C



>40C

DIMM

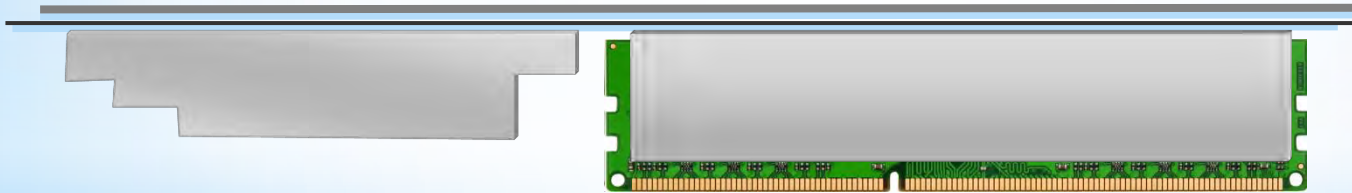
Hot air kills DIMMs

# Liquid

30C

30C

30C



Heat Riser

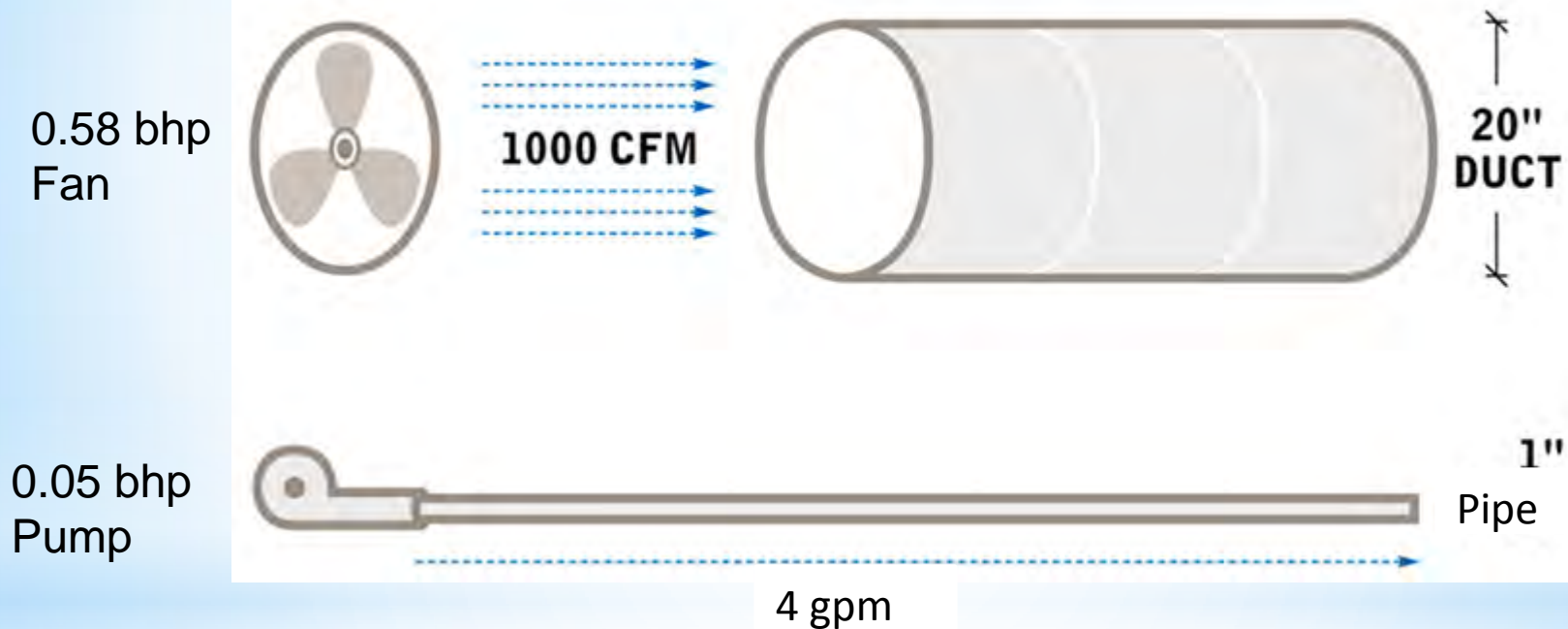
Jacketed DIMM

System is Isothermal

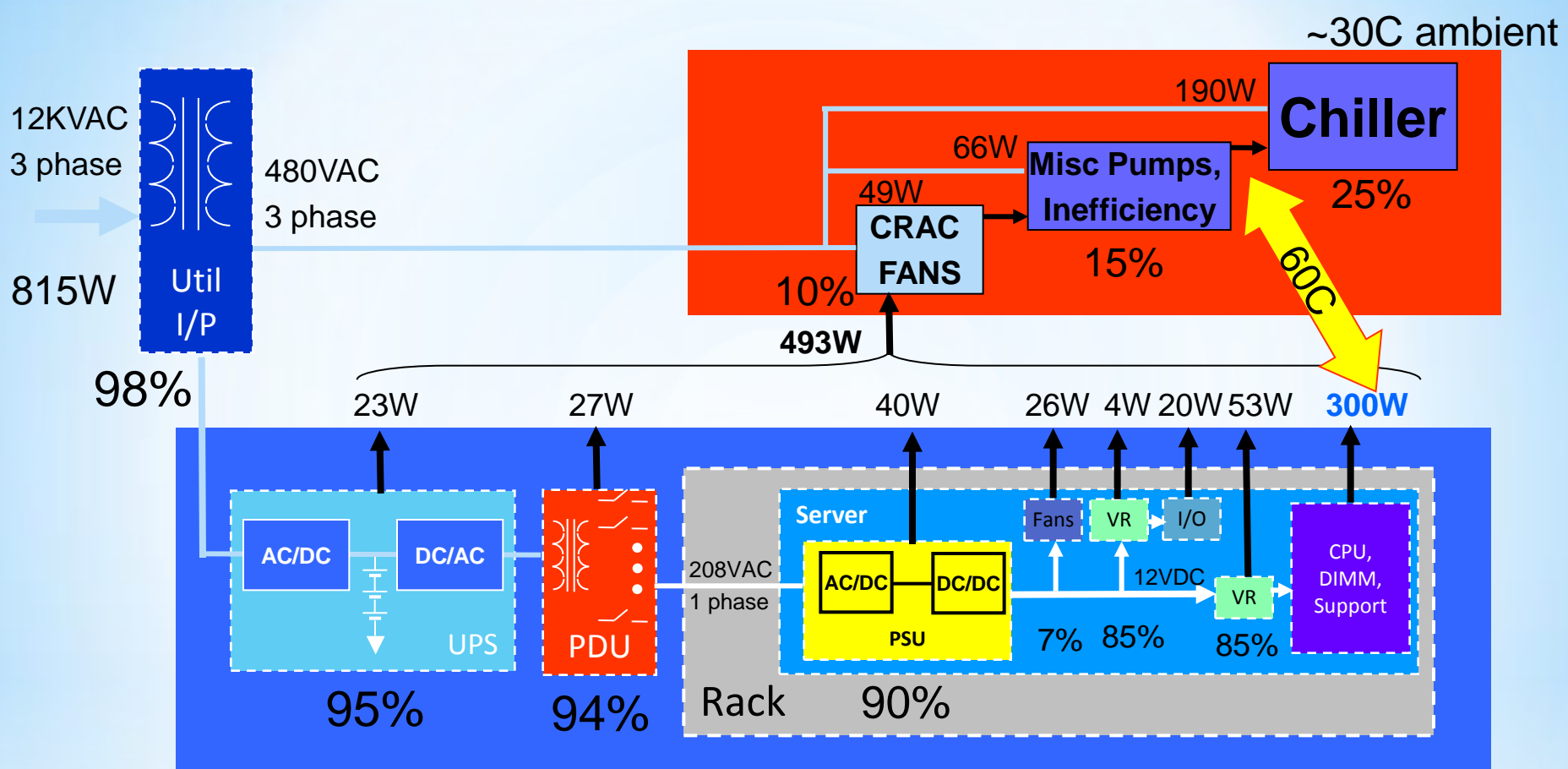
Cold Plate  
TIM  
Lid  
TIM

Shadows

# Fans Move Energy Less Efficiently



Flow		Formula	DT		BTUH	Eff	DP		Formula	BHP
1,000	cfm	$BTUH=1.1*cfm*DT$	21.8	°F	24,000	54%	2	in w.c.	$bhp=cfm*DP/(6350*eff)$	0.58
4	gpm	$BTUH=500*gpm*DT$	12.0	°F	24,000	80%	40	ft w.c.	$bhp=gpm*DP/(3960*eff)$	0.05



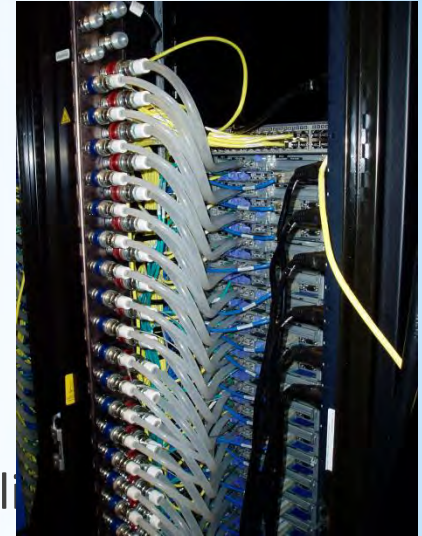
## Where the Power Goes: **Air**

\* Legacy air cooled system with water cooled chiller

- \* Eliminate air cooling and provide liquid cooling close to the heat source

- \* Solutions:

- \* Oil bath
  - \* Fluid all the way to the CPU
  - \* Fluid to the server



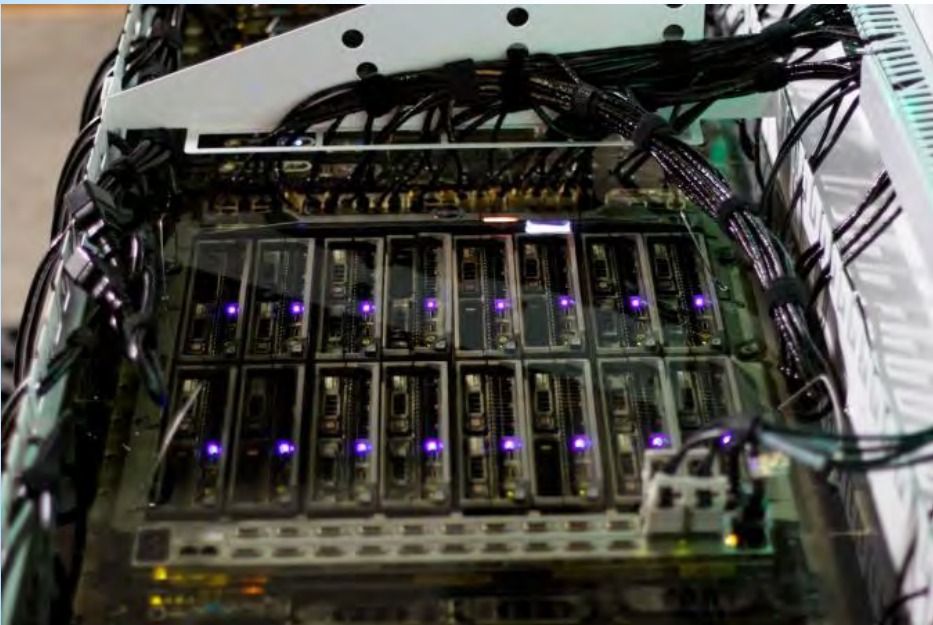
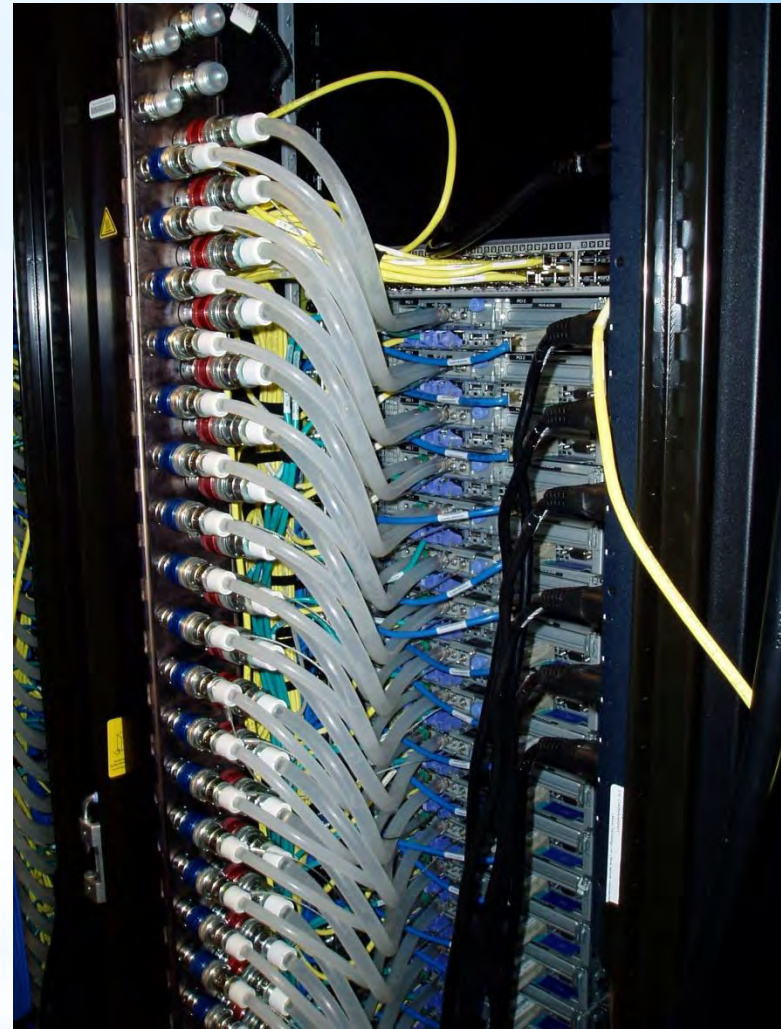
- \* Advantages:

- \* Efficiency improvement – ability to use warmer coolant
  - \* Better opportunity for use of waste heat

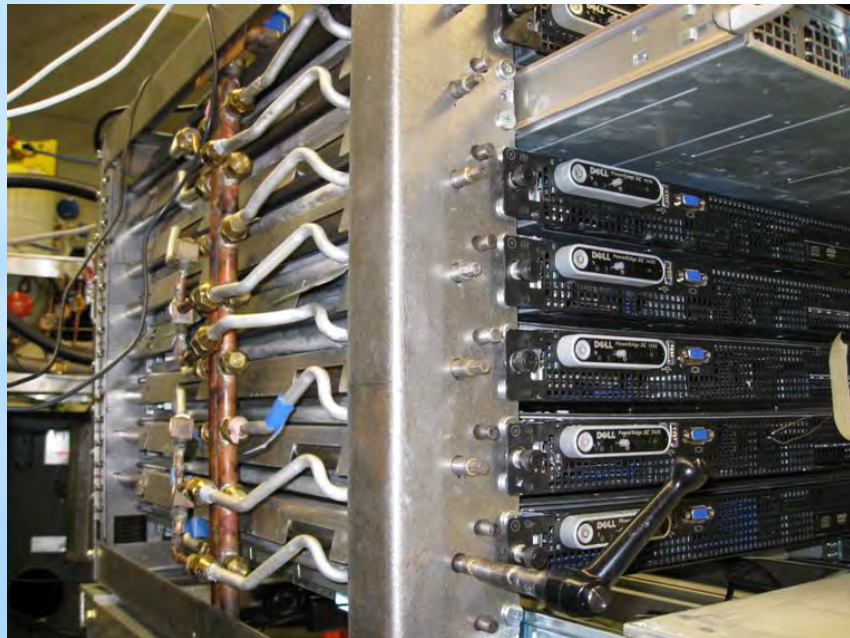
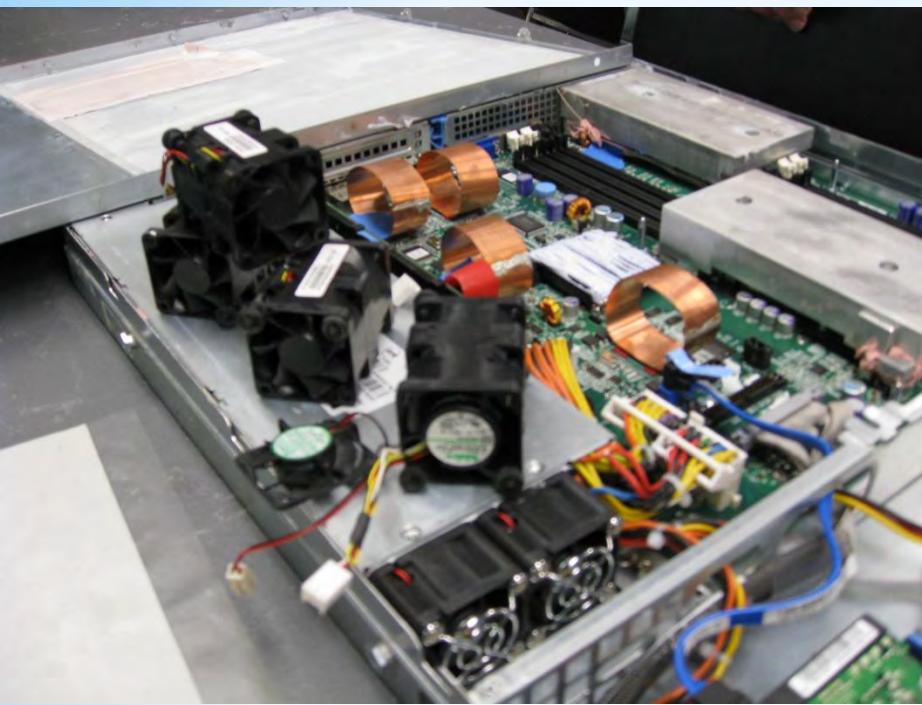
- \* Complicating factors:

- \* Expensive to install and maintain
  - \* Risk of fluid leaks

## Liquid Cooling Options



## Liquid Cooling Options



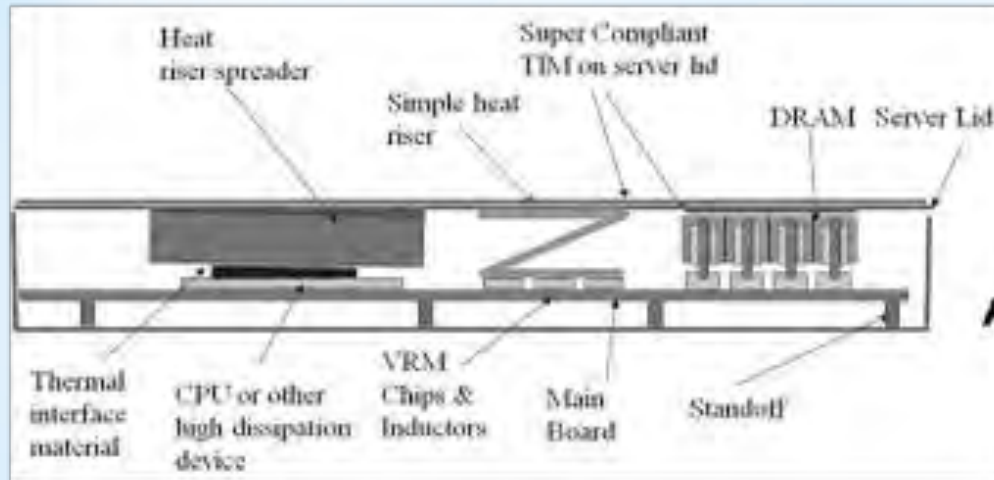
Proof of Concept then  
on to Demonstration

- \* Fluid does not enter the server
- \* Heat is transferred by conduction and convection to the lid of the server
- \* Specially designed cool plate in touch with the server lid – flexible to ensure contact
- \* Fans removed from the server and conductive materials added
- \* Not quite as efficient as fluid to the CPU but much less expensive
- \* Adaptable for 1U and Blade servers

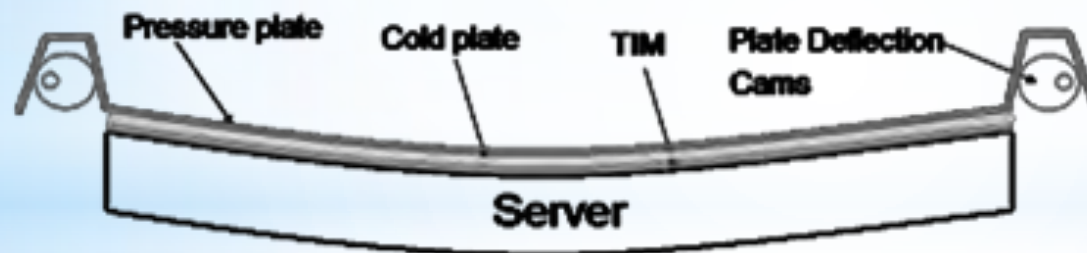
**Cooling solution**



**Cold Plate**



**Server Architecture**

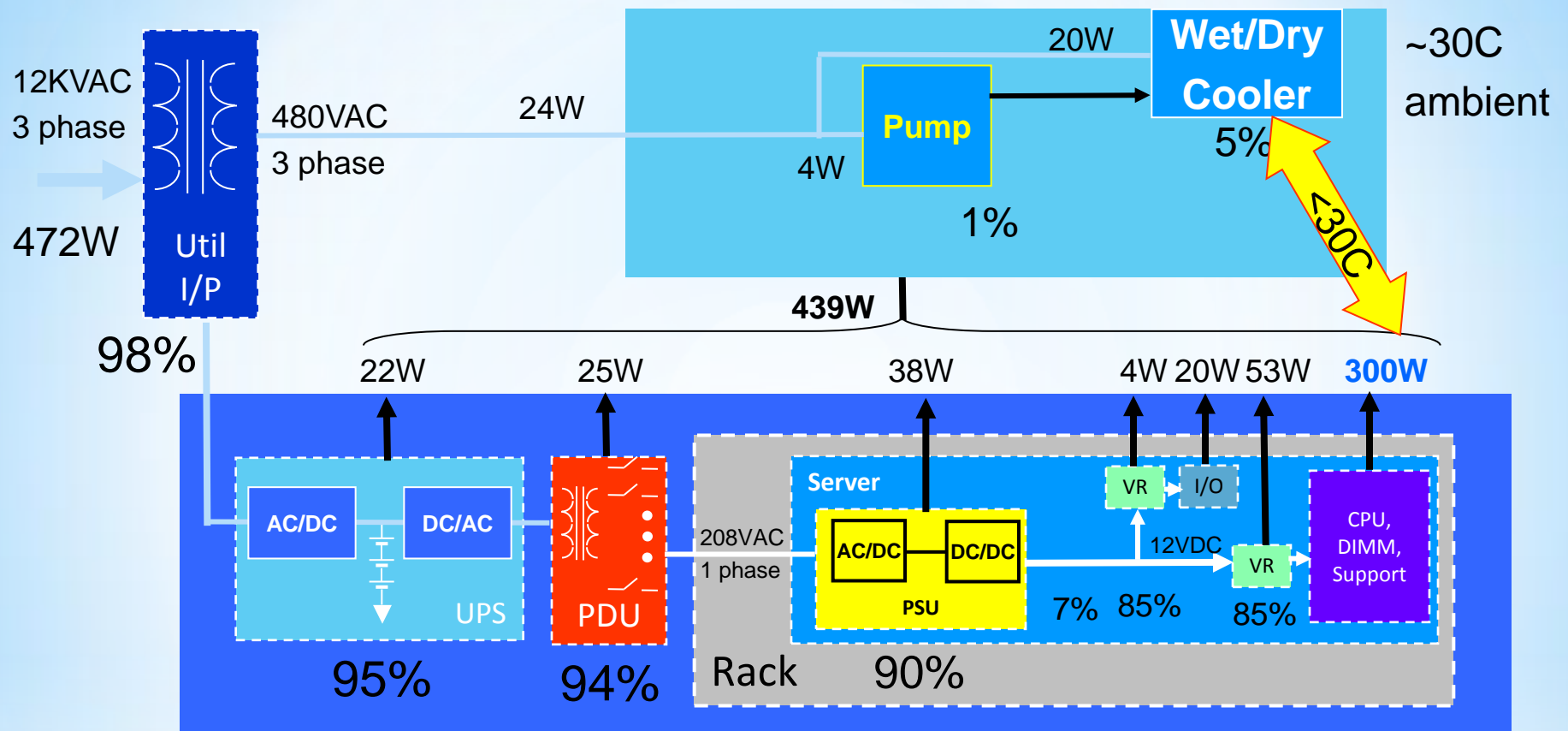


**Mechanism**



**Rack**

**“Direct Touch”**



## Where the power goes: Refrigerant

- \* All fans eliminated
- \* Lowered thermal resistance enables 95% economizer use or total chiller elimination

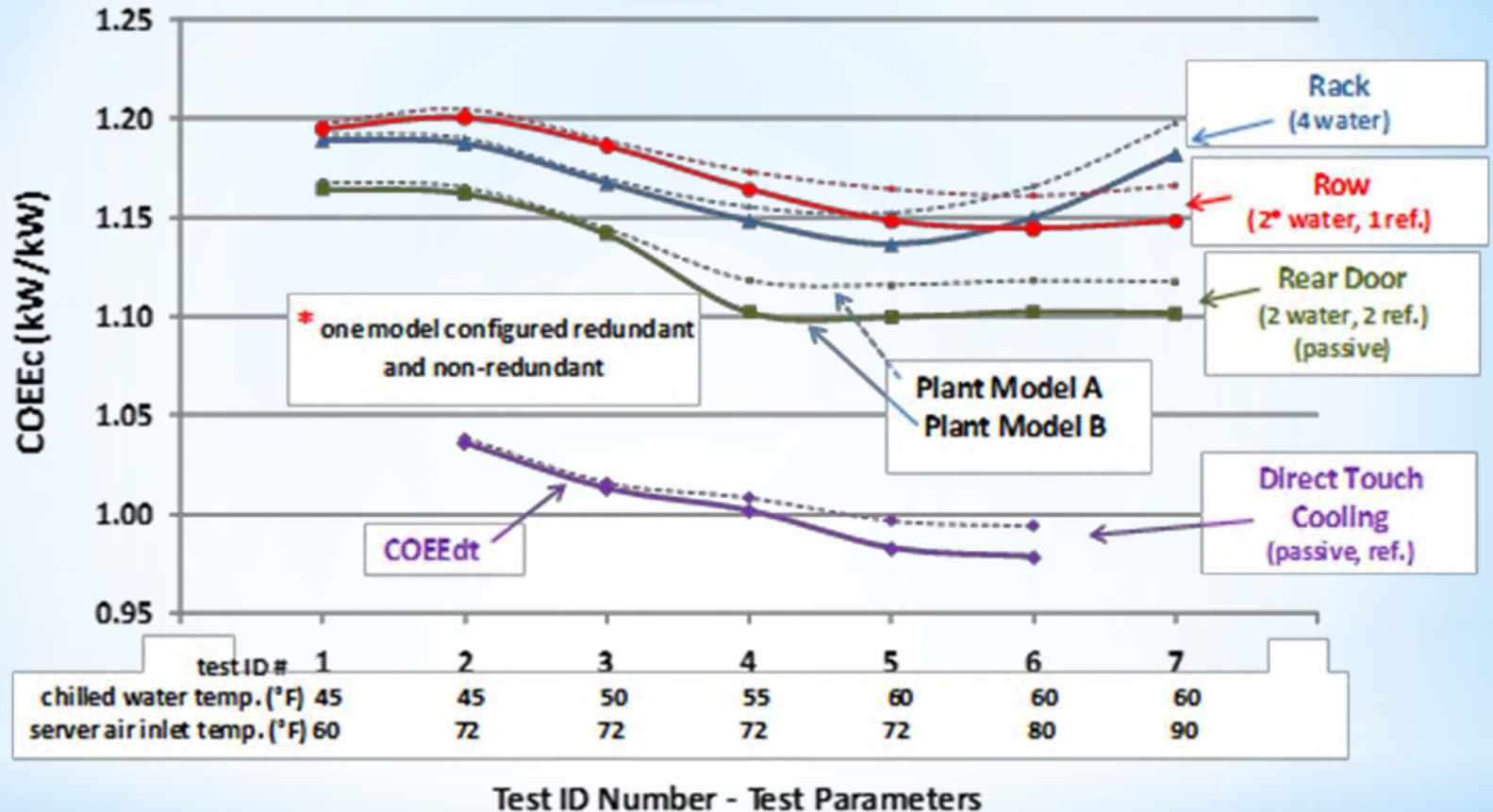
	<b>Air</b>	<b>Refrigerant</b>
Volume effect		
Server Fans	7% IT energy	-
CRAC Fans	10% I/P Energy	-
Pump		1% IT energy
Density	5 racks	1 rack
Rt effect		
Chiller	20%-35% I/P energy	<5%
Power Result*	815W	472W

\* Mileage will vary

 **Energy Scorecard**

## COEEc - All Devices - Type Group Average

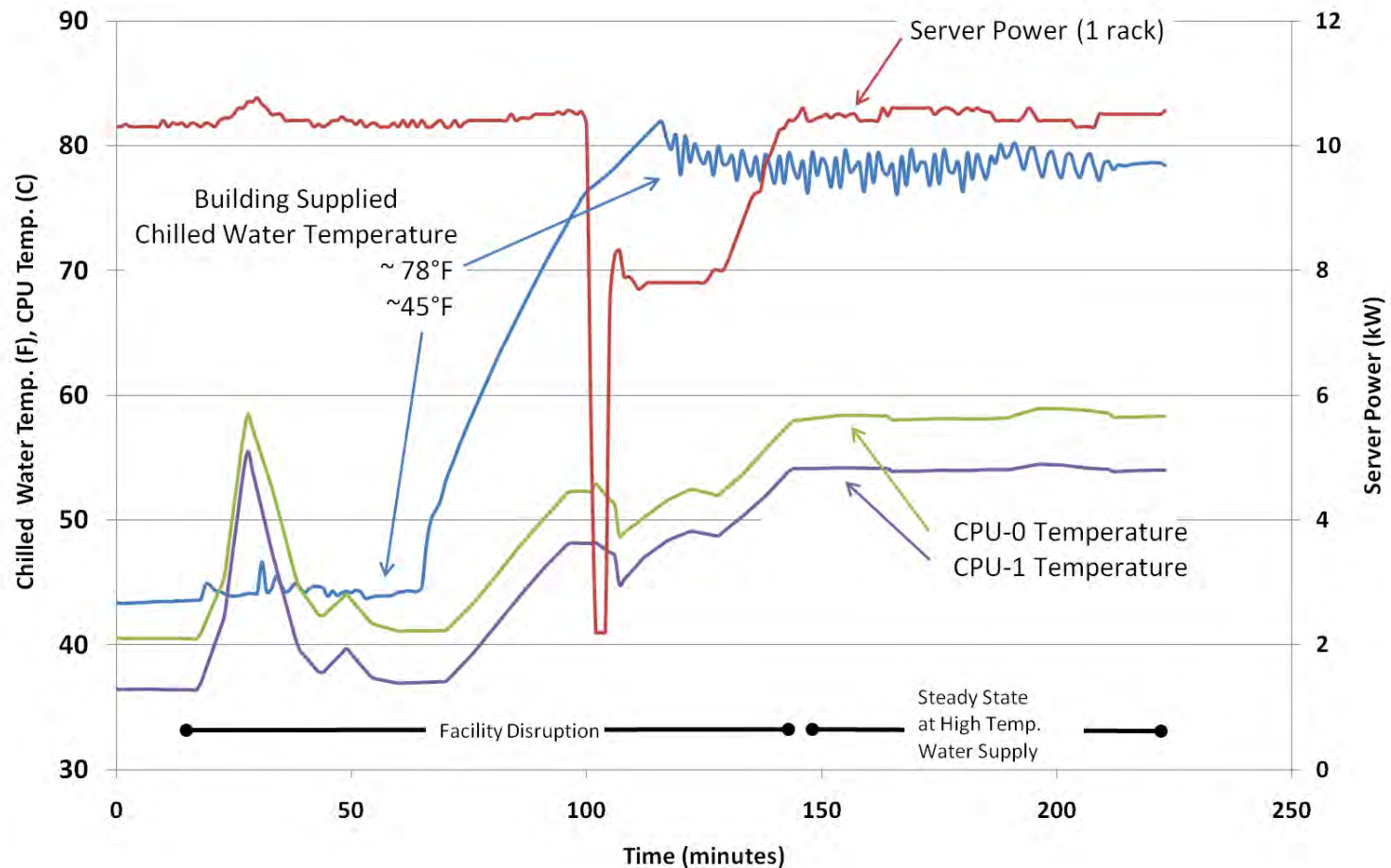
Chilled Water Plant A and B, No Water to Water CDU



Modular Cooling Closely Coupled to the Heat Source is Much Better than Standard Practice

“Chill Off” Findings

Unanticipated Cooling Interruption showed how potentially higher temperature cooling could be used for this system



- \* COEE less than 1 since fans removed from servers
- \* Potential 40% energy reduction in existing data centers
- \* Cooling capacity of racks exceeds 40KW
- \* Higher temperature coolant could be used
- \* Noiseless!

## Performance Results

- \* Direct Touch has been demonstrated to have the highest cooling efficiency
- \* Lower Capex for refresh and new builds
  - \* 1/5 Computer room floor space
  - \* Shorter cable, pipe runs
  - \* Lower power and cooling requirements
  - \* Simpler control systems
- \* Postpones large capital purchase
  - \* Add 50% more servers to existing facility
- \* Improved System Reliability
  - \* Improved reliability of HDDs, DIMMs; fan elimination
- \* AND: No Noise!

## Results Summary

- \* Viable economical solution for high density
- \* Potential to use higher temperature cooling fluid
- \* Eliminates much of the HVAC equipment – capital cost savings
- \* Lower server cost
- \* Can be implemented today



This presentation is based on a peer-reviewed paper (ML-11-C005), which is available in the onsite ASHRAE bookstore and through the online ASHRAE bookstore following the conference.

## Conclusion

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\* Questions ?